Verifying the EPIC calibration stability using invariant targets and using EPIC to radiometrically scale multiple MODIS and VIIRS sensors

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DSCOVR EPIC and NISTAR STM, Virtually, **September 28-30, 2021**

Background

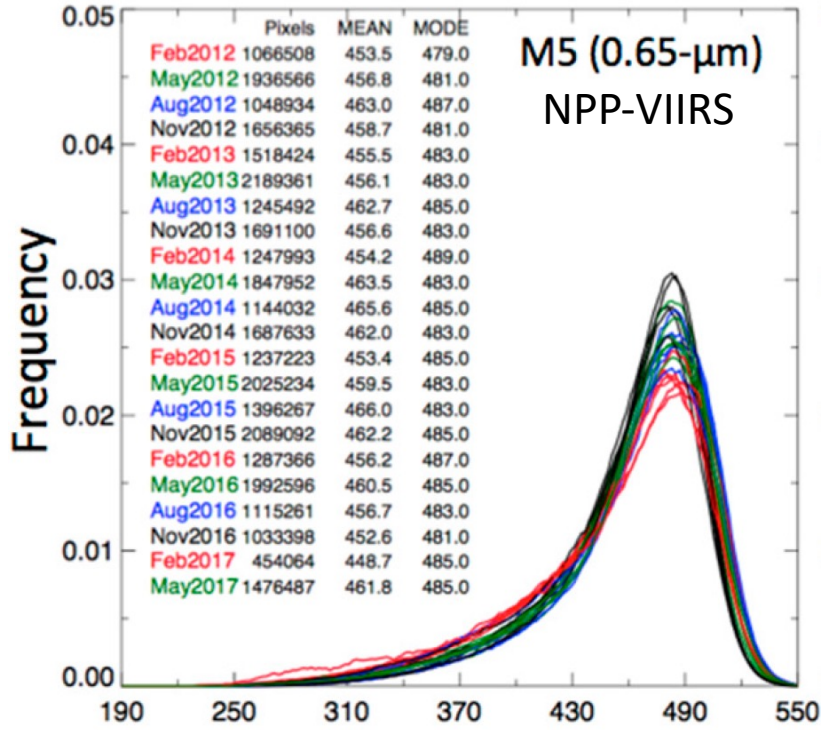
- NASA CERES project provides broadband TOA SW and LW fluxes to the climate community
  - For monitoring the Earth's energy balance and for validating climate model fluxes
- MODIS and VIIRS cloud retrievals are used to convert the CERES instrument radiance into fluxes
- The MODIS C6.1 and VIIRS C2 analogous channel reflectances are not radiometrically scaled
  - Absolute calibration based on the onboard solar diffuser
  - CERES will rely on the NOAA-20 flux record once the Aqua and Terra orbits will drift outside of their 15-minute local time control box
  - The consistent MODIS and VIIRS cloud retrievals are needed to have a seamless transition of CERES observed fluxes between Aqua and NOAA-20 records require radiometric scaling
- Since MODIS and VIIRS are in forward processing mode, calibration drifts are embedded in the record
  - These are corrected in the next collection

Outline

- MODIS and VIIRS calibration stability assessment and drift correction algorithm
- Radiometric scale NPP and NOAA-20 VIIRS with MODIS analogous channels using ray-matching methods
- DSCOVR-EPIC sensor calibration stability assessment using Libya-4 and deep convective cloud (DCC) invariant targets
- The use of DSCOVR-EPIC sensor to validate the MODIS and VIIRS calibration drift correction and radiometric scaling algorithms
  - Due to the EPIC's diurnal image sampling capability, it can be inter-calibrated with MODIS and VIIRS imagers

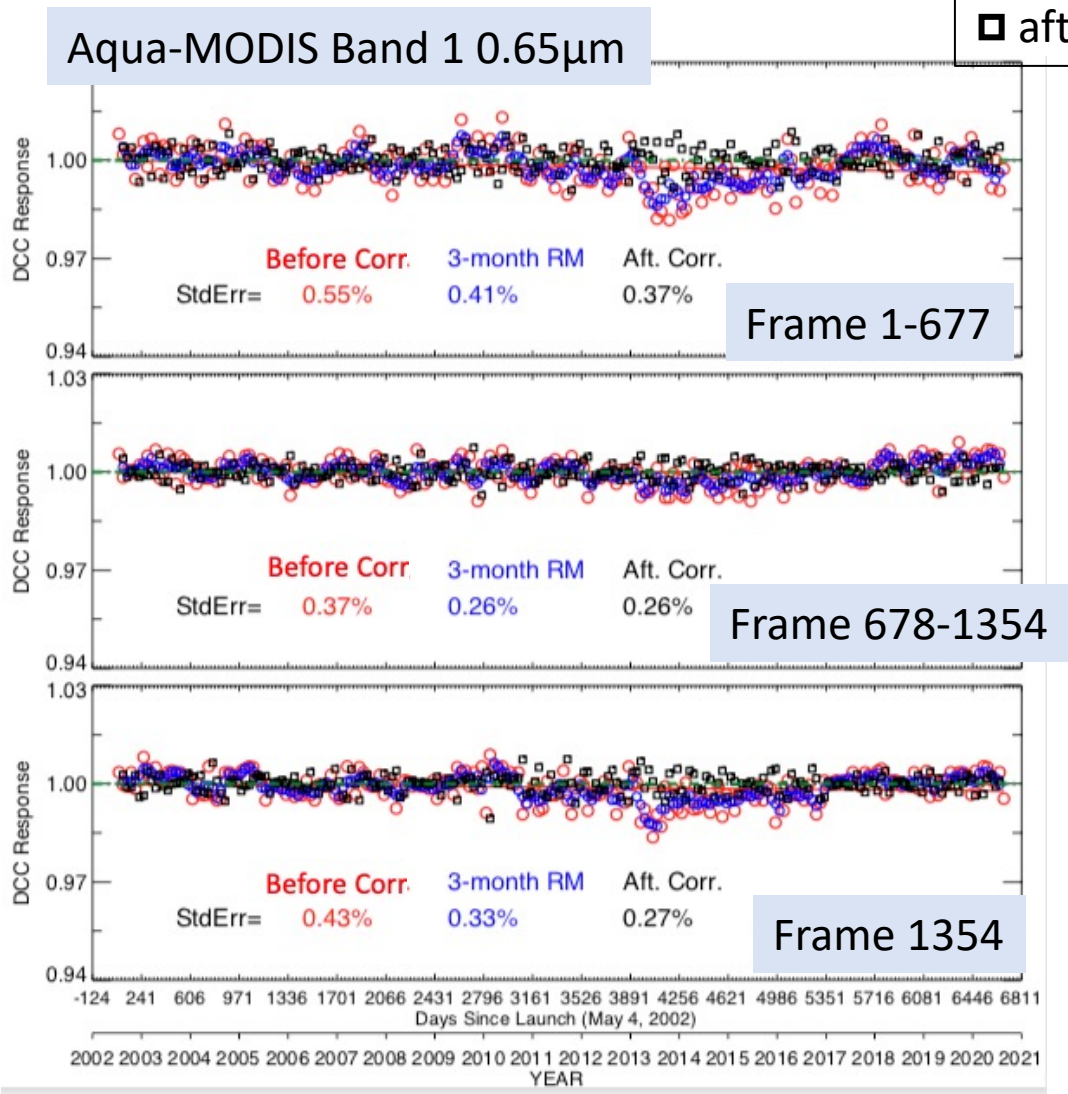
MODIS DCC-IT before and after calibration drift correction

DCC-IT target method used to assess stability



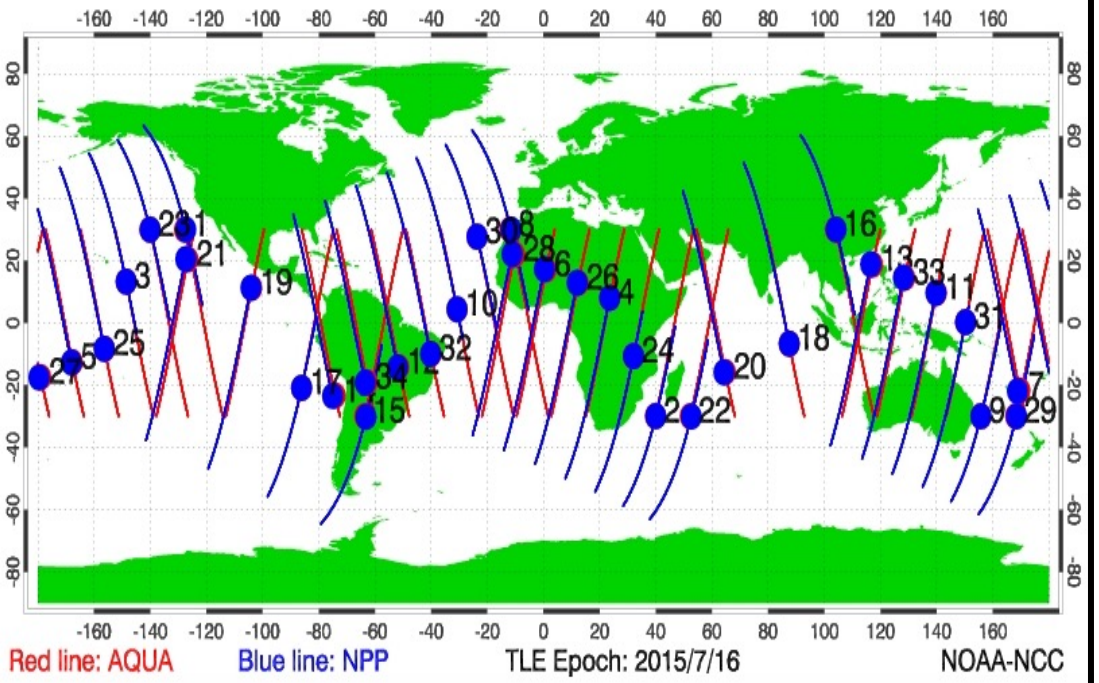
- All of the DCC pixel radiances over the month are histogrammed
- Use the monthly DCC mode to track stability

o Before
o 3-month
□ after



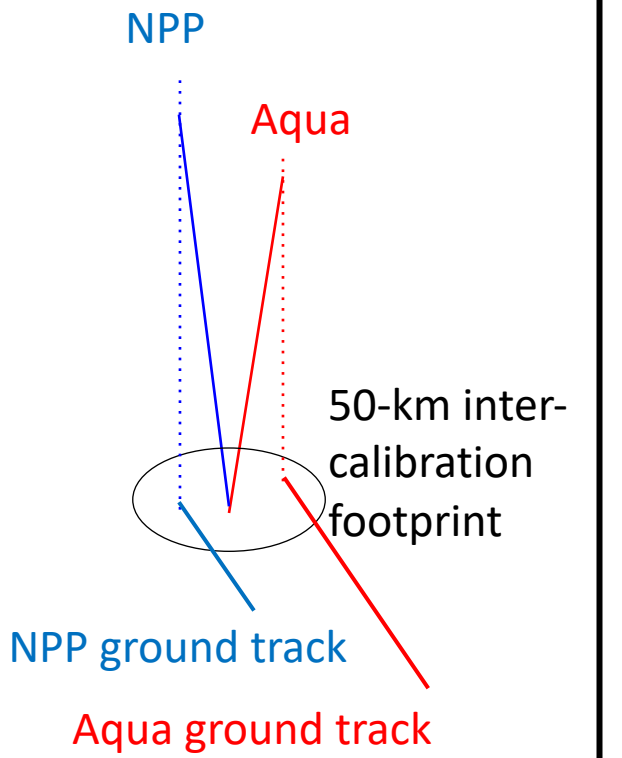
MODIS and VIIRS tropical ATO-RM and DCC-RM algorithm

NOAA web site tropical Aqua and NPP SNOs
For July 16, 2015

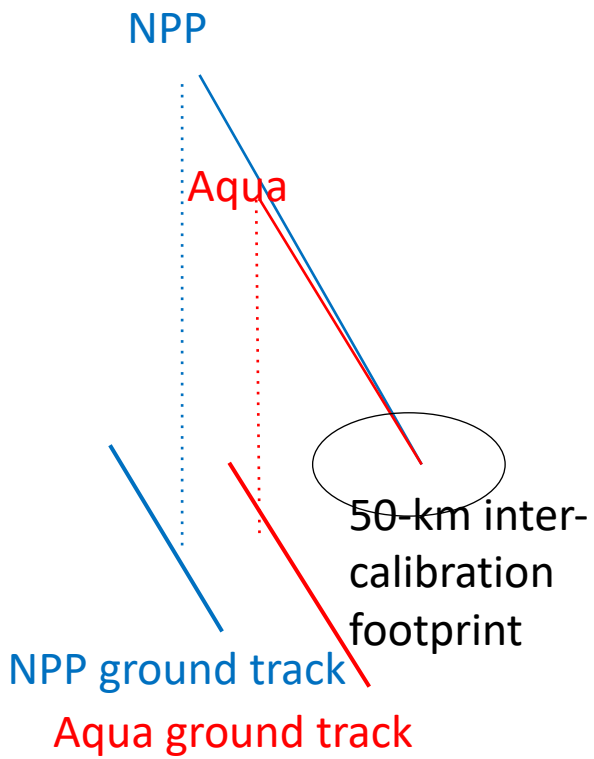


The NPP and Aqua orbit intersects are coincident in time every 64 hours

Tropical Ray-matching geometry



Footprint in between the NPP and Aqua ground tracks

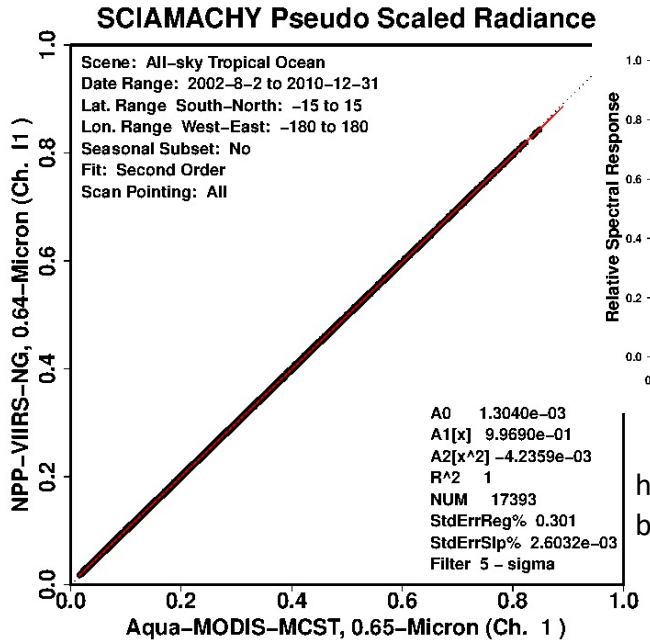


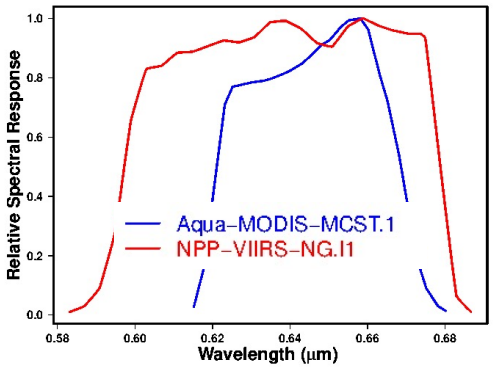
NPP and Aqua groundtracks on same side of footprint

ATO-RM and DCC-RM algorithms

All-sky Tropical Ocean-raymatching (ATO-RM)

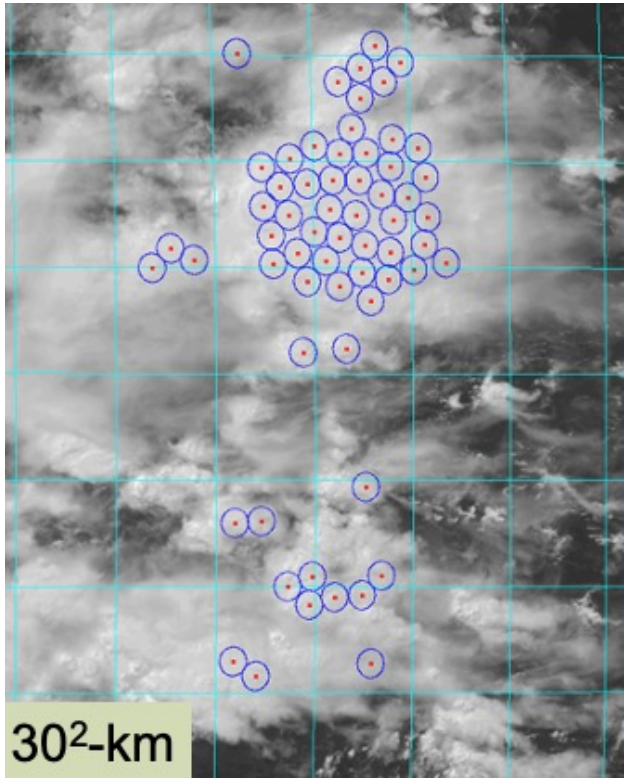
- Grid both the MODIS and VIIRS visible pixel ocean reflectances into 0.5° latitude by longitude grid
- Angle or ray match the MODIS and VIIRS grid regions
- Apply a spectral band adjustment factor (SBAF) to VIIRS match the MODIS spectral response function





https://satcorps.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=SBAF

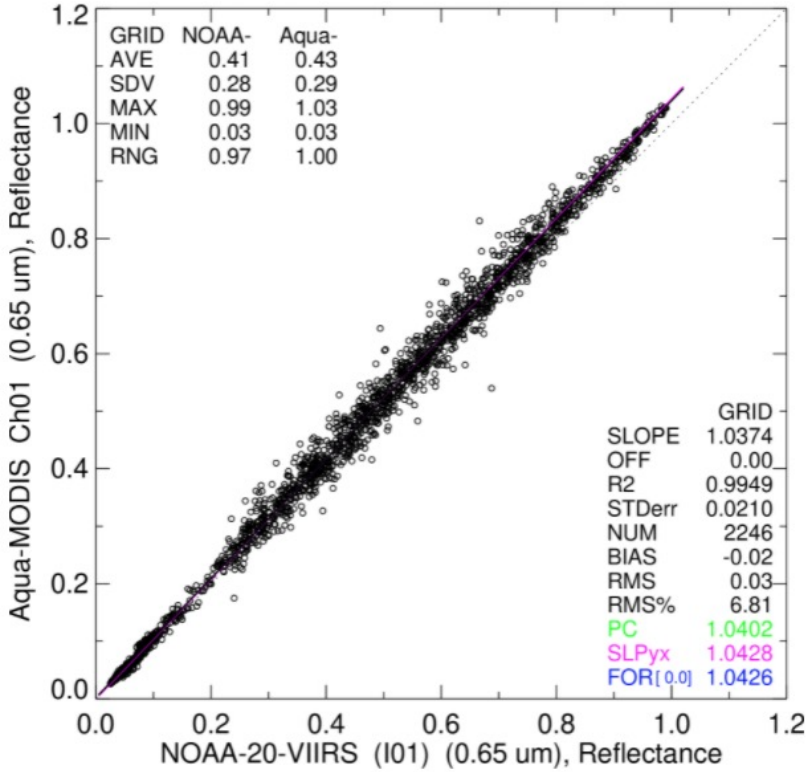
Deep Convective Cloud raymatching (DCC-RM)



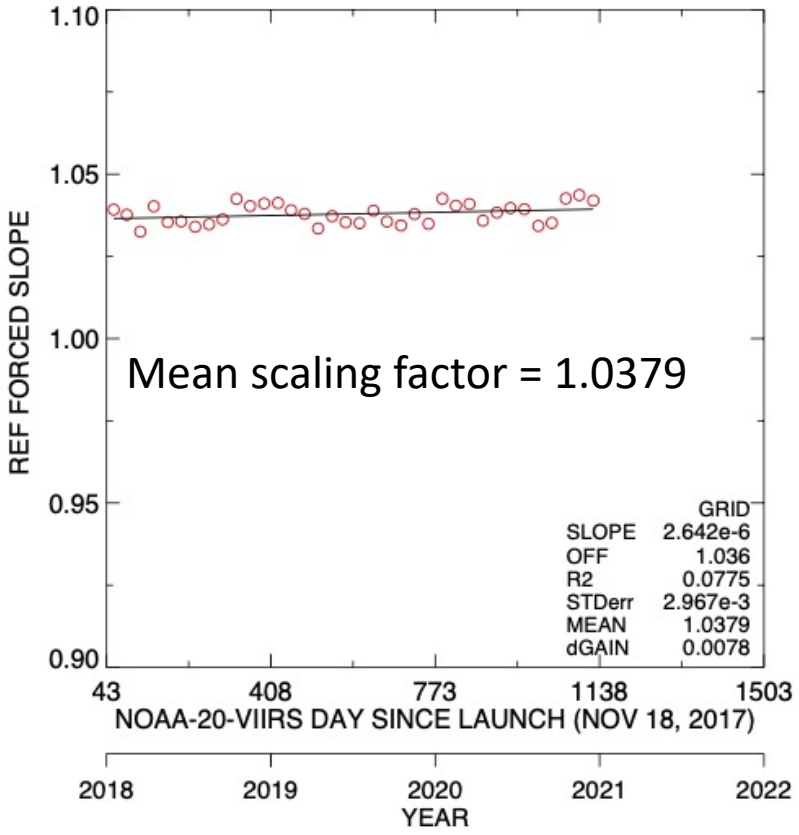
- Find the coldest 11μm BT pixel in a granule and average the all of the visible pixel reflectances within a 30-km diameter
- BT<205K
- σRef<5%
- σBT<1K
- Repeat and find the next coldest 11μm BT pixel until the all DCC cells have been found
- find the MODIS and VIIRS angle match cells
- Apply SBAF

MODIS and VIIRS tropical ATO-RM and DCC-RM algorithm

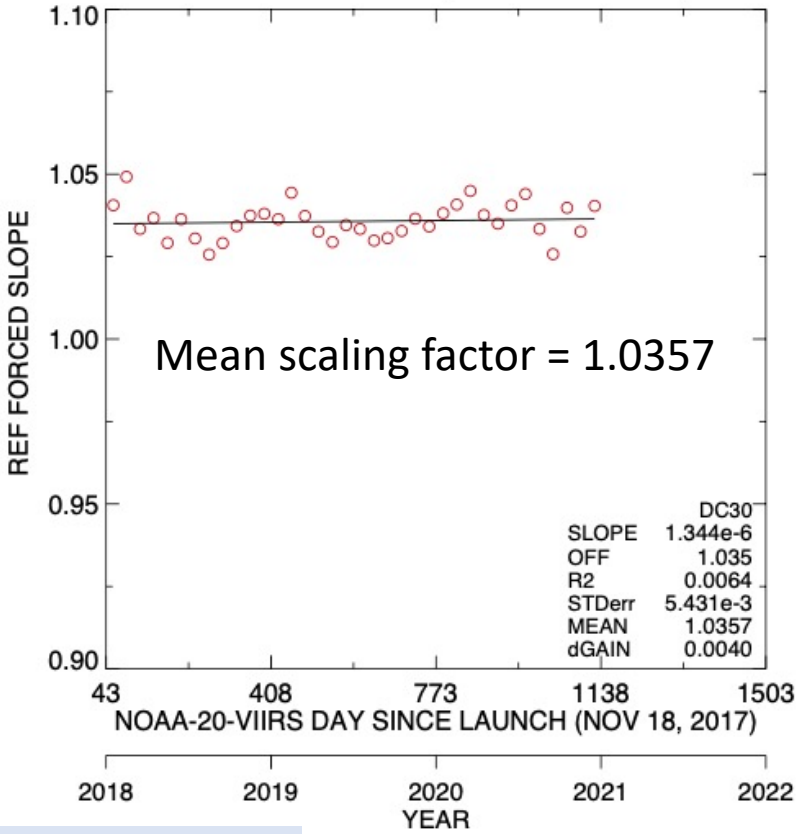
ATO-RM, MODIS B1 and N20 I1
January 2020



Aqua-MODIS-B1 and N20-VIIRS-I1
ATO-RM



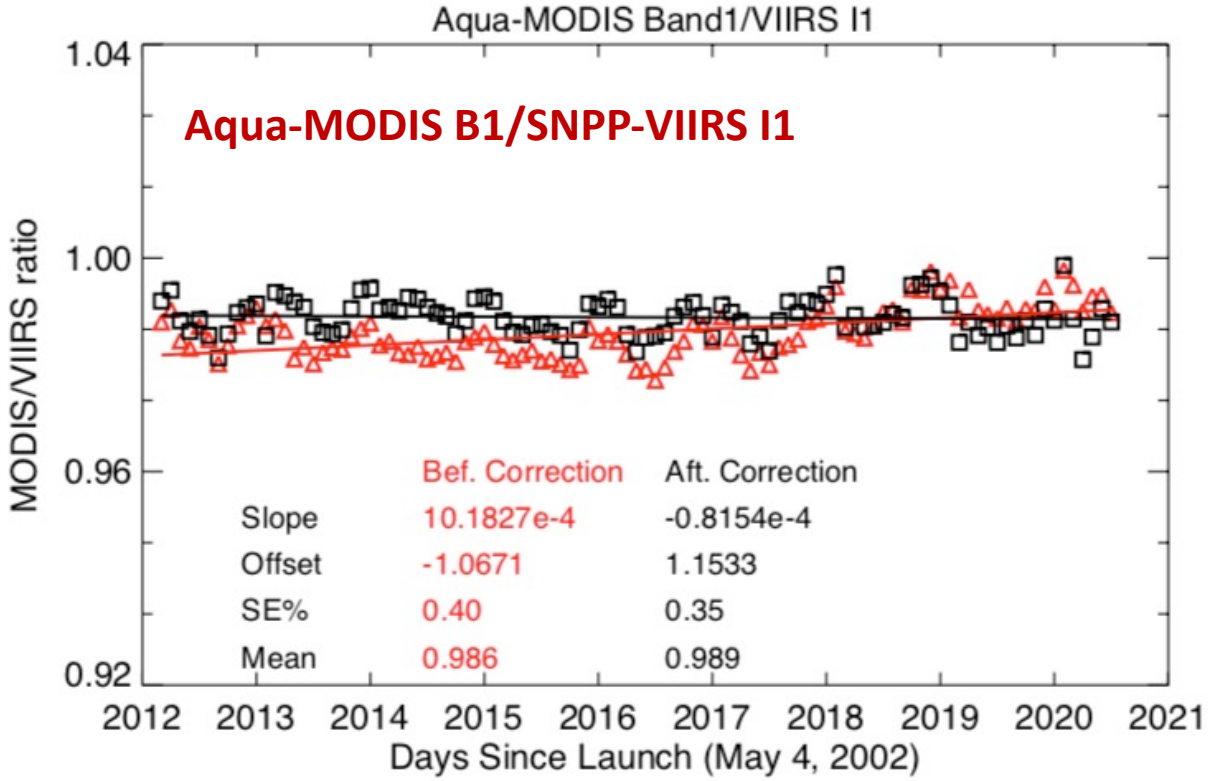
Aqua-MODIS-B1 and N20-VIIRS-I1
DCC-RM

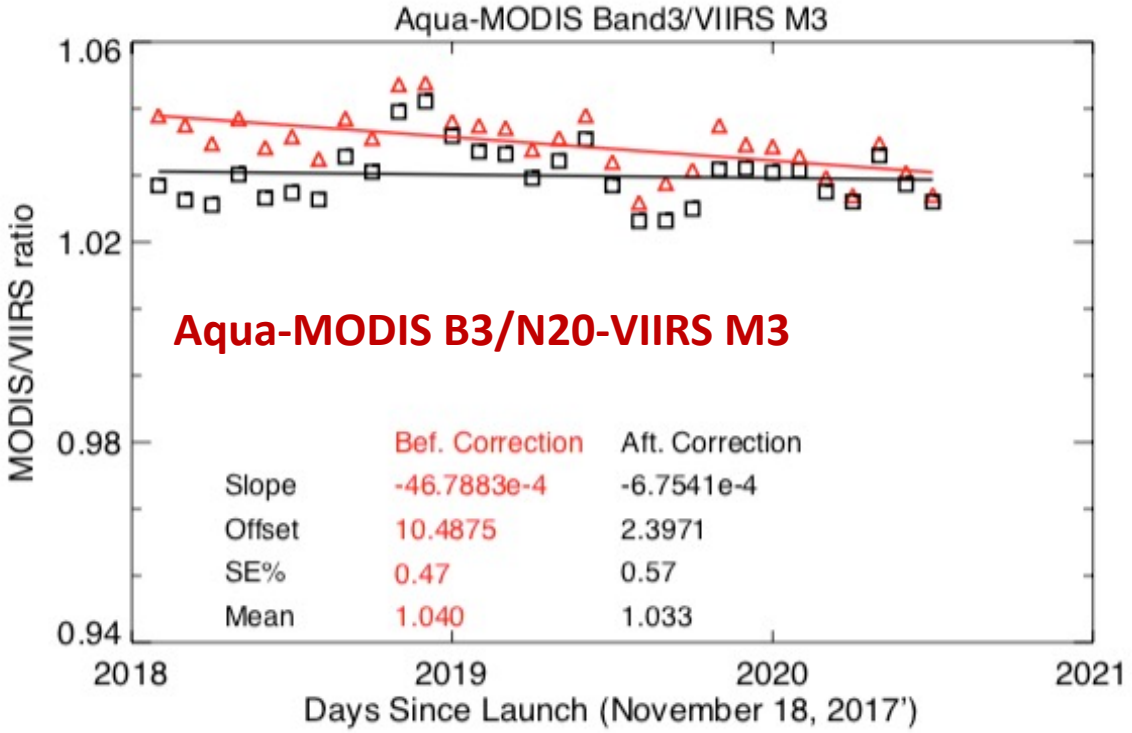


ATO-RM and DCC-RM mean scaling factors are within 0.2%

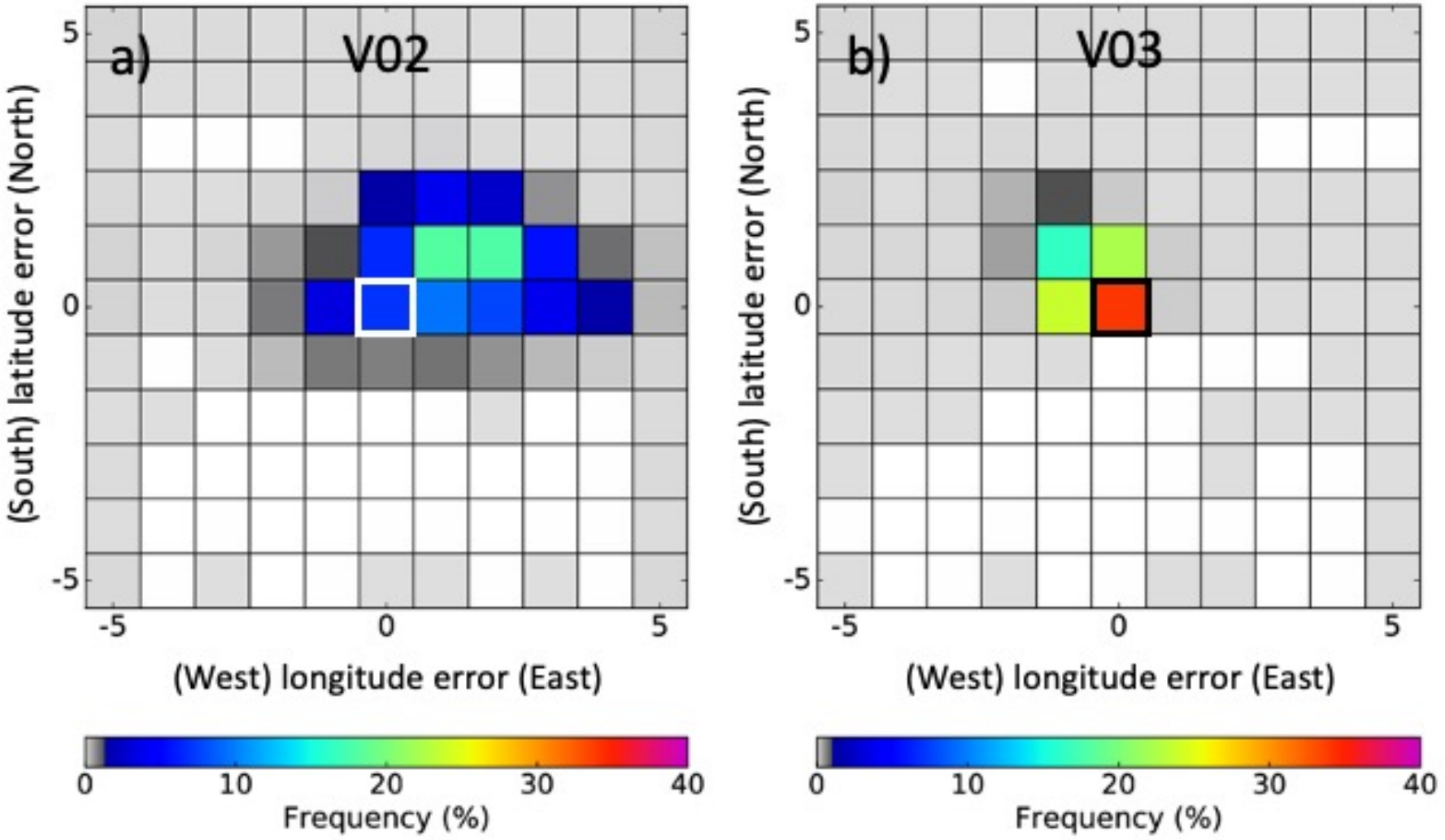
Validation of the MODIS and VIIRS drift corrections

- Before drift corrections the MODIS and VIIRS ratio may have embedded trends, after drift correction the trend ratio should be mitigated
- If the MODIS and VIIRS trend is stable then only a one-time scaling factor between the MODIS and VIIRS is needed





EPIC V2 vs V3 navigation improvement

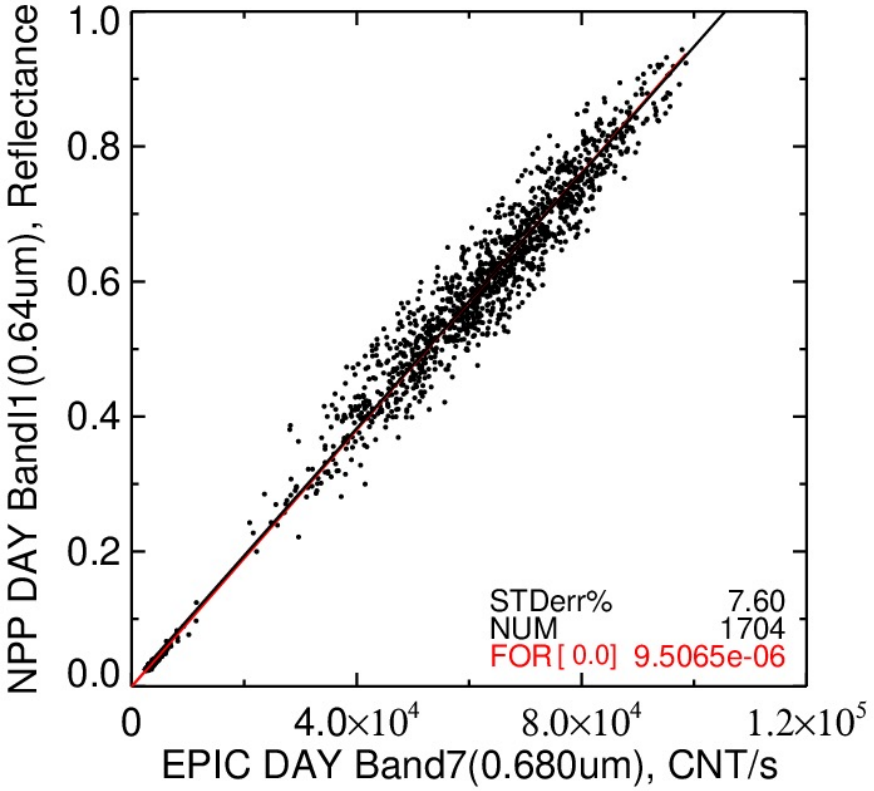


Grid EPIC, MODIS and VIIRS imager pixels into 0.25° grid cells

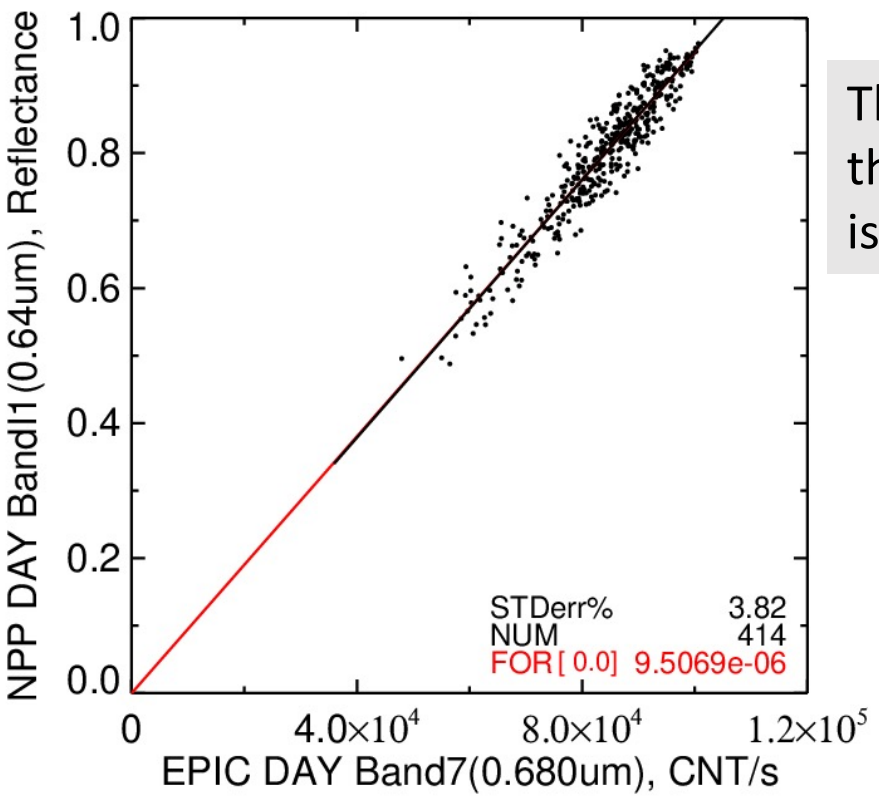
Align the EPIC grid with the MODIS or VIIRS grid, by linearly regressing EPIC and MODIS 0.25° radiances, find EPIC image adjustment with largest r^2

EPIC and VIIRS ATO-RM and DCC-RM consistency

ATO-RM EPIC and NPP 0.65µm November 2011

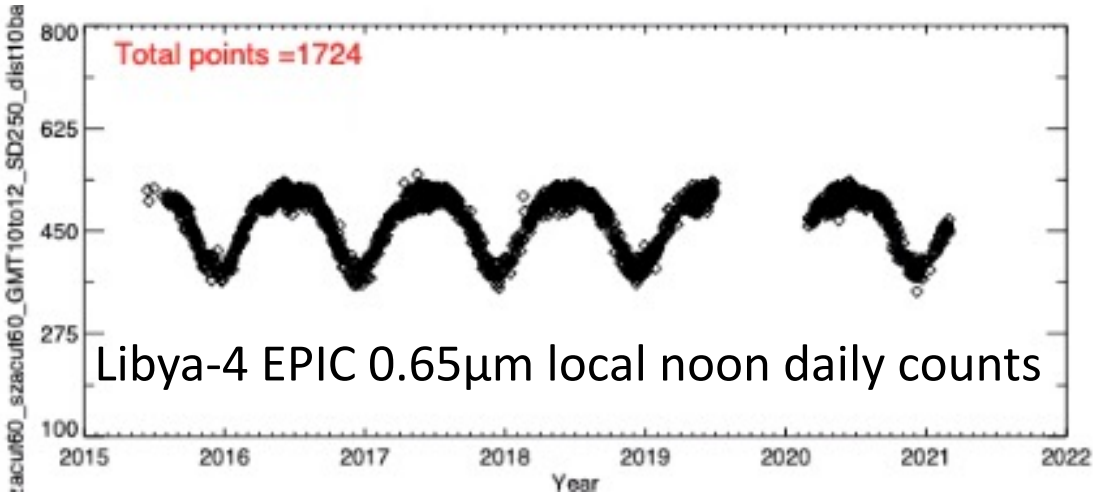


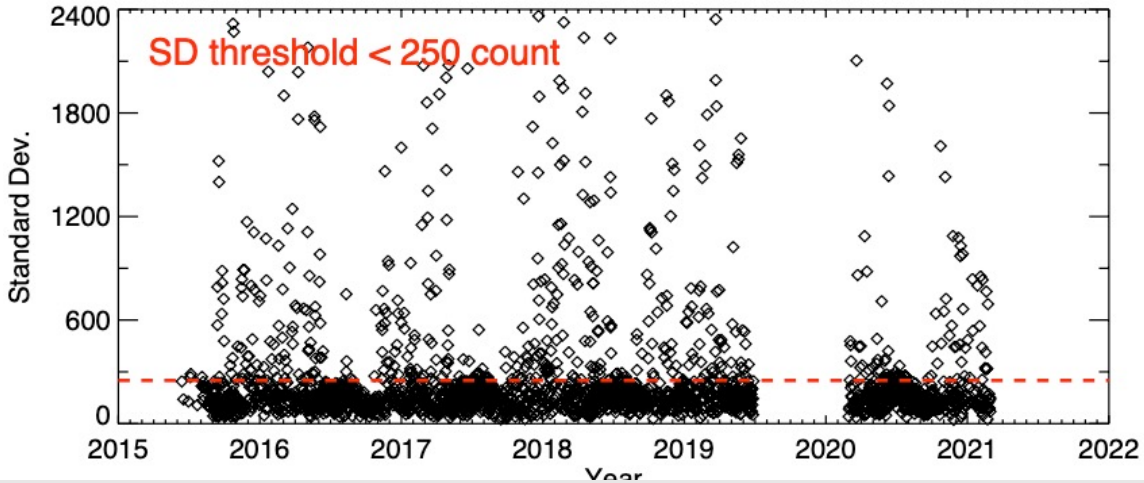
DCC-RM EPIC and NPP 0.65µm November 2011



The linear fit (red line) through the offset of 0 is almost identical

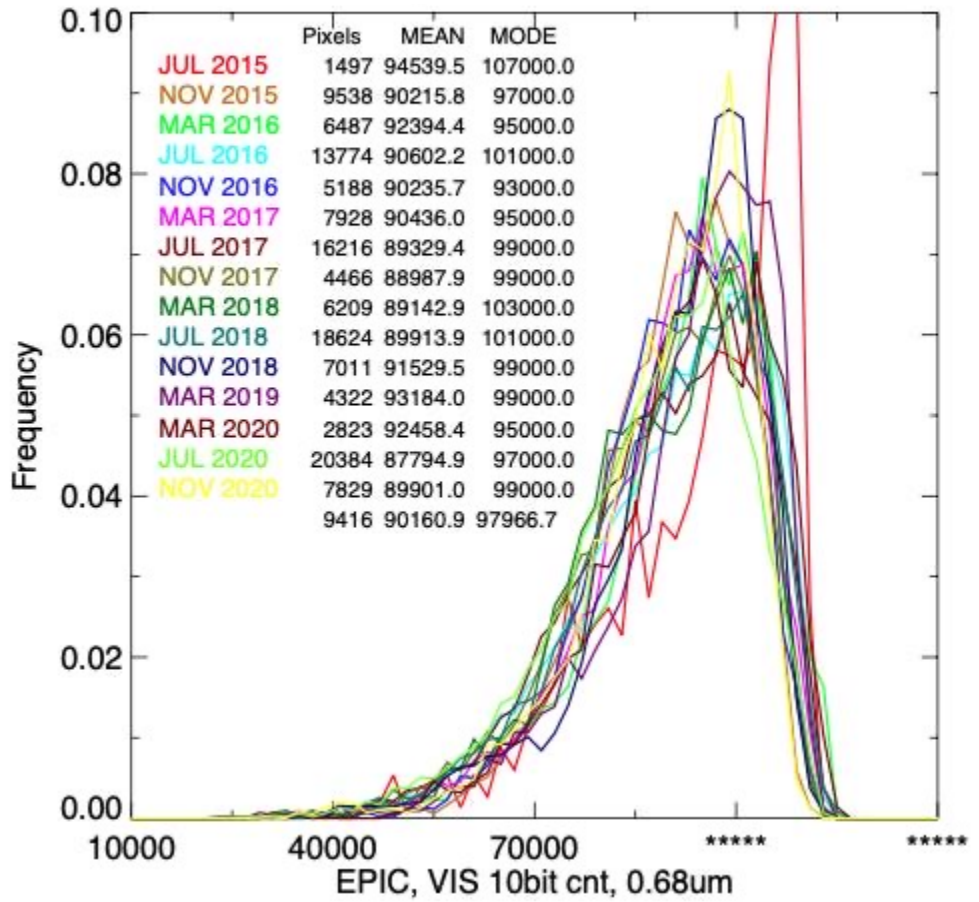
EPIC Libya-4 and DCC-IT





Libya-4 relative sigma to determine clear-sky conditions
Use Libya-4 BRDF to normalize Libya-4 reflectances to overhead sun

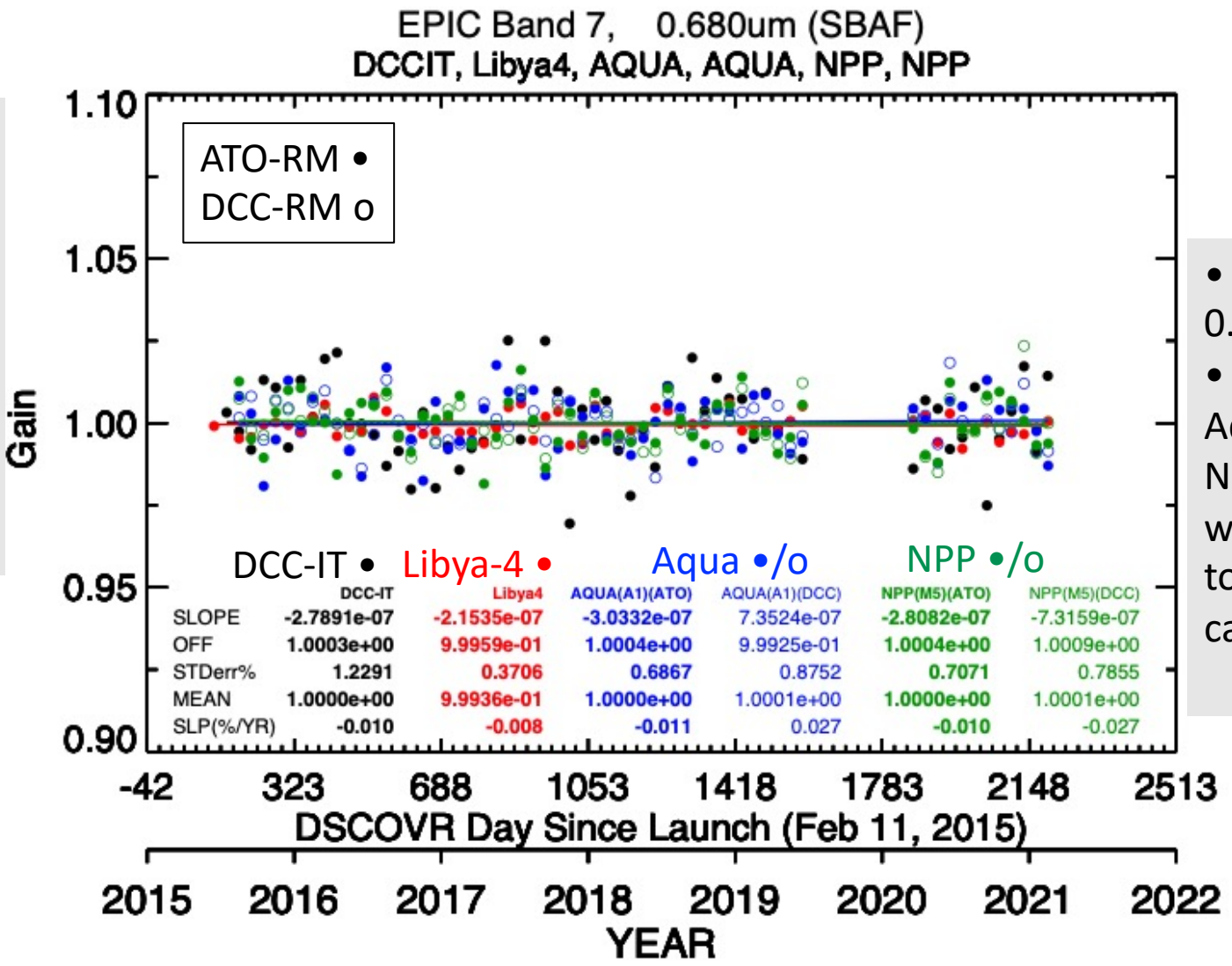
Monthly EPIC 0.65µm DCC-IT PDFs



- Use MODIS or VIIRS IR 11µm BT<220K matched with EPIC pixels to identify DCC targets
- The DCC-IT PDF mode is very noisy.
- For EPIC use the DCC-IT PDF mean to track stability

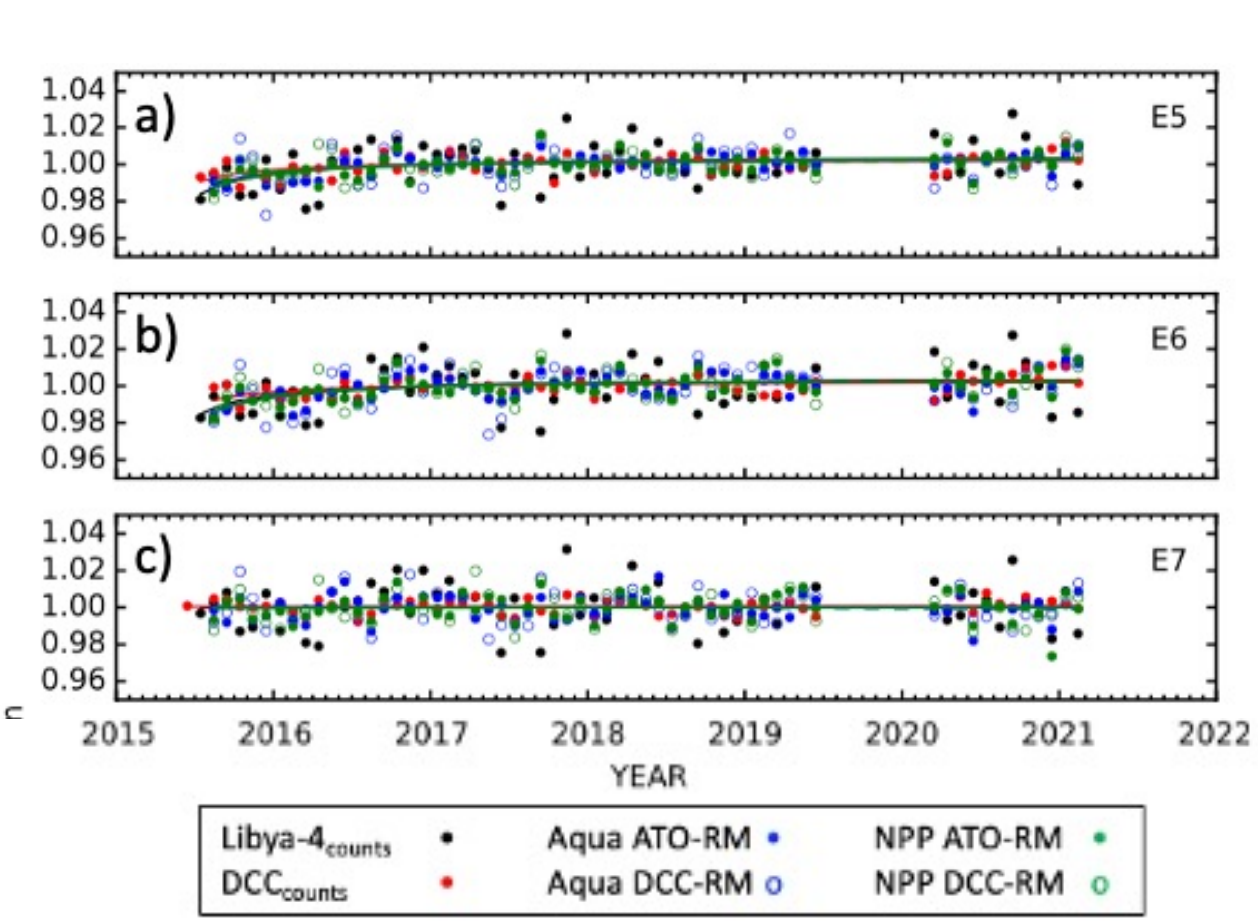
EPIC stability assessment of MODIS and VIIRS

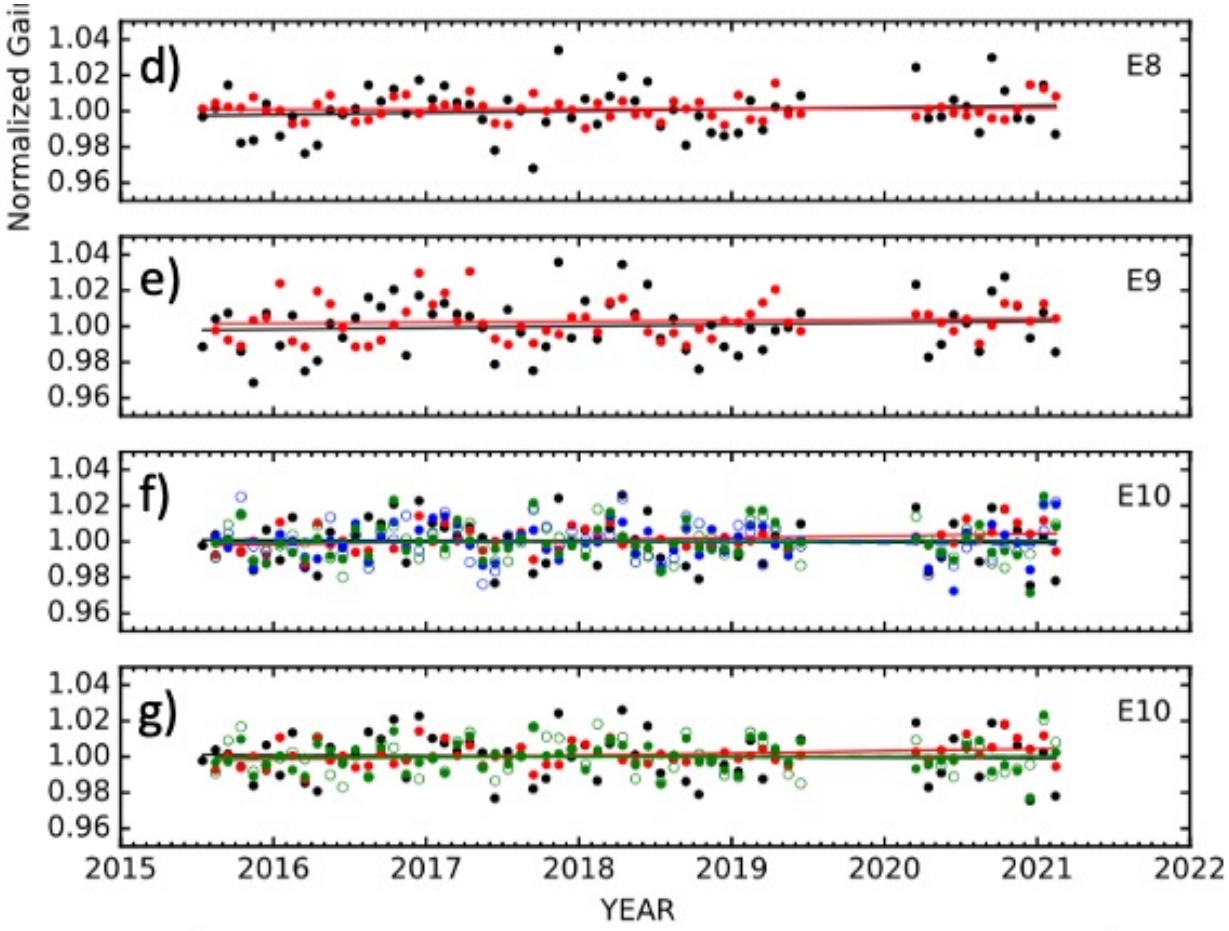
- DCC-IT and Libya-4 invariant targets do not rely on MODIS or VIIRS stability
- Libya-4 and DCC-IT indicate the EPIC band 7 (0.64µm) is stable



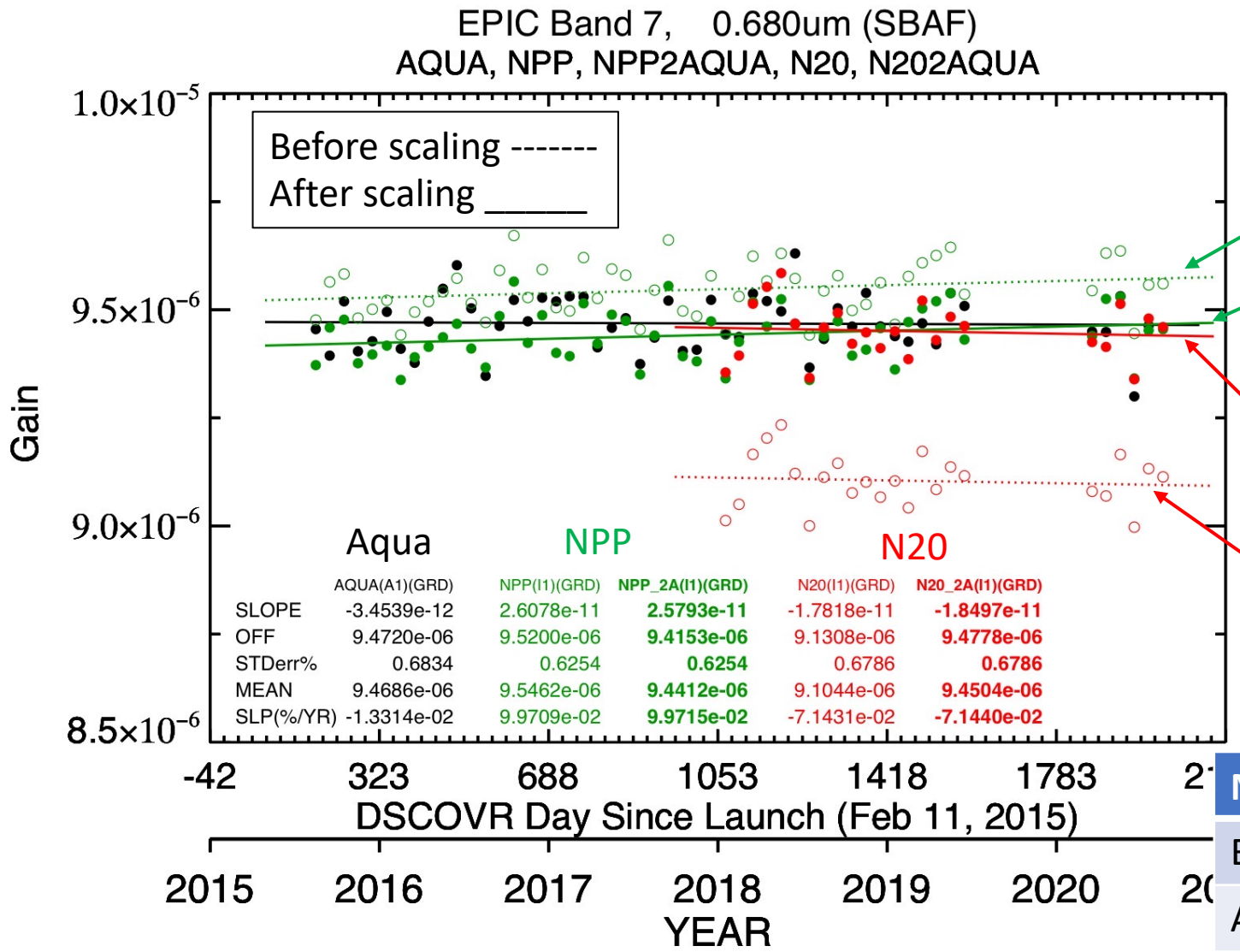
- All linear trends within 0.03%/year
- DCC-IT, Libya-4, Aqua MODIS ATO-RM and DCC-RM NPP VIIRS ATO-RM and DCC-RM were normalized over the record to take out the absolute calibration difference

EPIC stability assessment for channels 5 through 10





Before and After Radiometric Scaling to Aqua-MODIS



Aqua-MODIS is the reference for radiometric scaling

NPP VIIRS before scaling

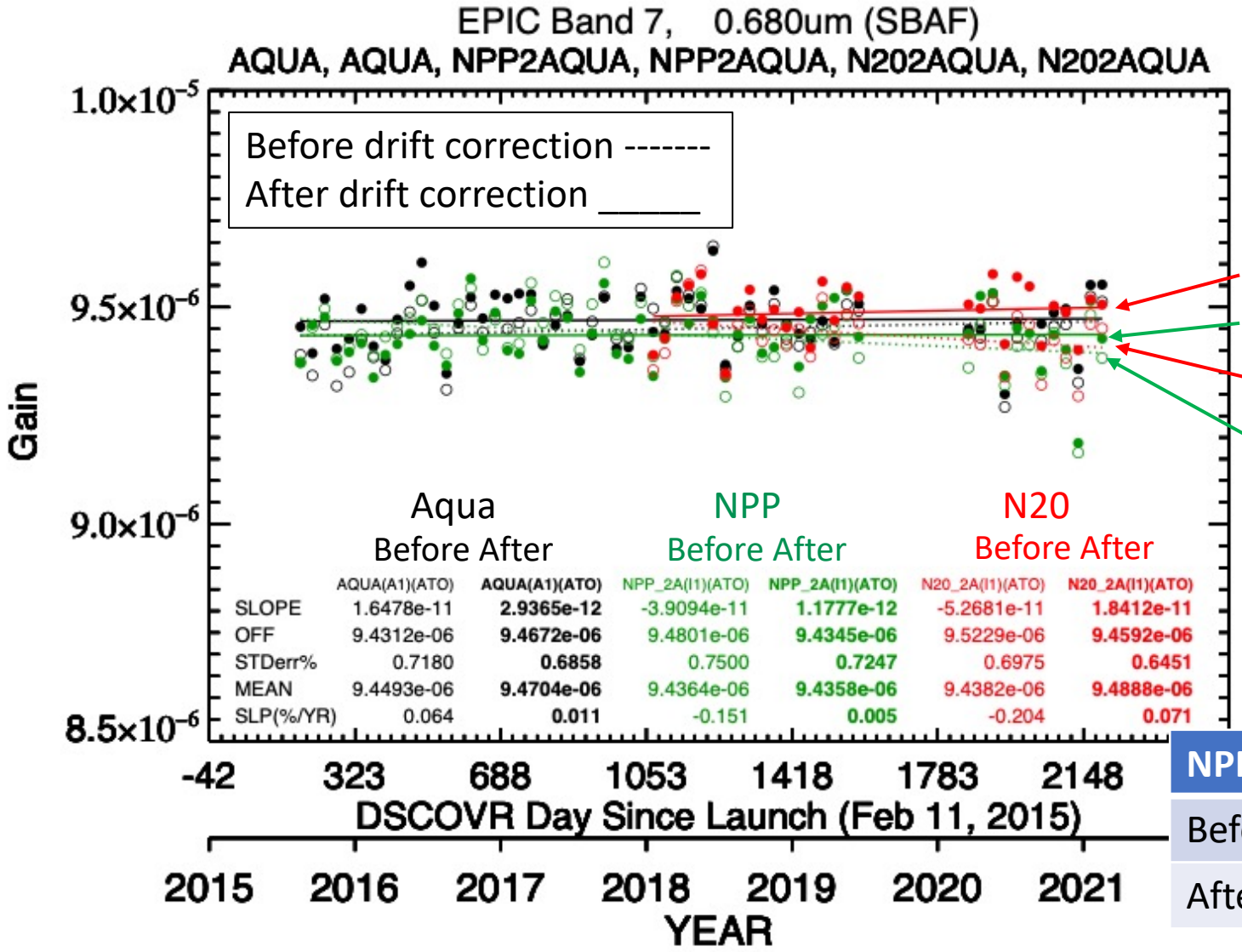
NPP VIIRS after scaling

N20 VIIRS after scaling

N20 VIIRS before scaling

NPP	NPP	N20
Before scaling	0.82%	-3.85%
After scaling	-0.29%	-0.19%

Before and After MODIS and VIIRS drift correction



N20 VIIRS drift corrected

NPP VIIRS drift corrected

N20 VIIRS before drift correction

NPP VIIRS before drift correction

Also, smaller linear trend standard errors after drift correction

NPP (%/yr)	Aqua	NPP	N20
Before drift	+0.06	-0.15%	-0.20%
After drift	+0.01	+0.01%	+0.07%

Conclusions

- DCC and Libya-4 invariant Earth targets indicate the EPIC is a stable sensor
- The EPIC sensor can be inter-calibrated with all sun-synchronous, precessing
  - EPIC can be used as a transfer radiometer
  - EPIC can be used as an invariant target to monitor MODIS and VIIRS radiometric scaling and drift corrections
  - EPIC can monitor the calibration stability of NPP, N20, N21 VIIRS sensors even though the VIIRS sensors will coincident observations and when Aqua starts drifting